INF2178
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Assignment 4

1. Introduction

In this research, we would like to explore data of MRI results of patients with and without dementia by using mixed-effects (both within-subjects and between-subjects) one-way and two-way ANOVAs, and also calculate its statistical power.

There are three main research questions in our exploration:

1. Does the MRI result of first and second visits differ from each other?
2. Does with or without dementia affect MRI results of first and second visits?
3. Does gender affect MRI results of first and second visits?

2. Data Cleaning and Wrangling

The raw data contains 16 columns and 294 rows. After reviewing the dataset, some columns are not used in this analysis. The column Subject ID, Group (nondemented , demented, or converted), Visit (1st or 2nd), M/F (male or female), eTIV (estimated total intracranial volume), and nWBV (normalize whole brain volume) are used. Besides, since we are focusing on the difference between visits, data having only one visit is deleted. To make the dataset easier to explore, we create new data with columns ID, Group, M/F, eTIV_1, eTIV_2, nWBV_1, nWBV_2.

3. Analysis of Variance (ANOVA)

For each research question, we would draw plots (boxplot, swarmplot, and distribution plots for repeated measures ANOVA, and point plot for mixed-design ANOVA) to visualize our dataset. To make sure running ANOVAs in this case is reliable, we have to apply some tests to make sure that the dataset satisfied the assumptions. The assumptions of repeated-measures ANOVAs are sphericity, normality, homoscedasticity (using Levene test), and independently (true for this dataset). On the other hand, if there are more than two groups and the p value is less than 0.05 so we reject the null hypothesis, we would then use post-hoc tests with FDR-BH corrections to see where the difference is.

Research question 1

To discover whether first and second visits have a difference in MRI results, we would like to use one-way repeated measures ANOVA with the column Visit to the value in column eTIV and nWBV.

From the plots below, we can see that the distribution of eTIV between two visits are slightly different. The p-value for this one-way repeated measures ANOVA test is 0.002, which is much less than 0.05. Therefore, we reject the null hypothesis and say that the mean of

estimated total intracranial volume is different when comparing the results of the first and second visit. Since there are only two visits, the p-value of the post hoc test FDR-BH corrections have the same p-value as the ANOVA test. And for the assumptions, the sphericity is 1.0, the variance of two visits are equal, but the distribution of both visits are not equal.

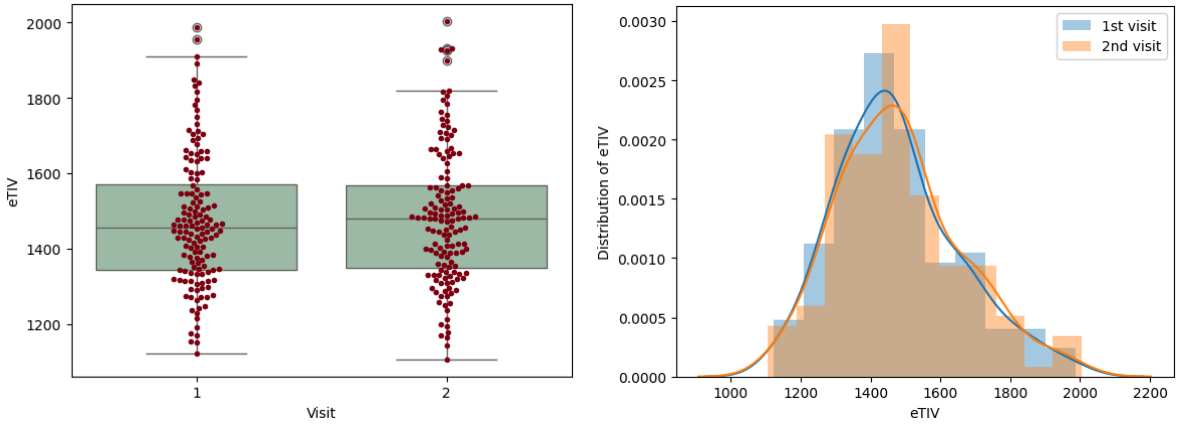

Figure 1: boxplot with swarmplot and distribution plot of eTIV grouped by number of visits.

And for nWBV, compared to the plot of eTIV, we can see that the distributions are more different. The p-value of the ANOVA test is 2.460952e-17 < 0.05, we also reject the null hypothesis and say that the mean of normalized whole brain volume is different between first and second visit. Same as above, the p-value of the post hoc test has the same p-value as the ANOVA test. For the assumptions, the sphericity is 1.0, the variance of two visits are equal, and the distribution of both visits are normal.

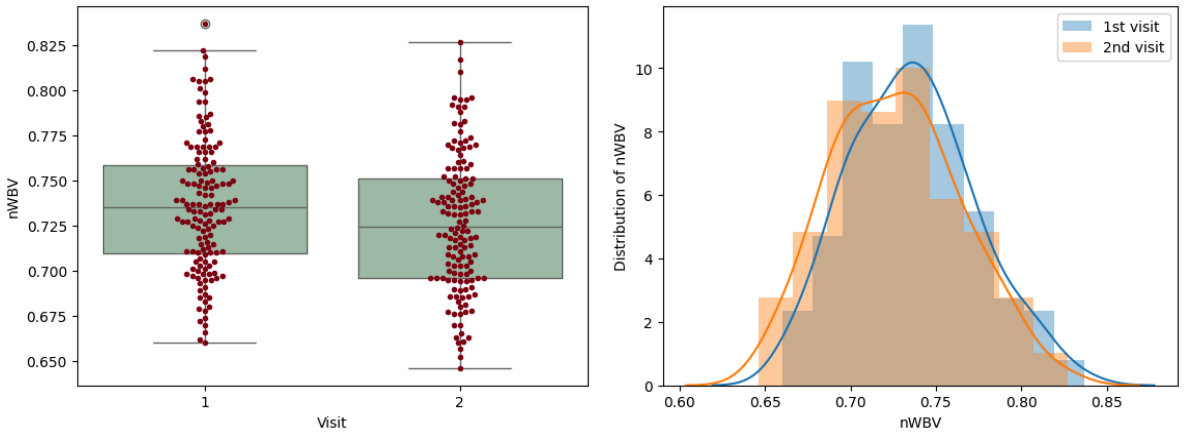

Figure 2: boxplot with swarmplot and distribution plot of nWBV grouped by number of visits.

Research question 2

To discover whether dementia affects MRI results of first and second visits, we would like to use a mixed ANOVA test with eTIV and nWBV value as the variable, visit as the within-subject factor, and the column Group as the between factor.

From Figure 3, we can see that the converted group has a lower value of eTIV. For the interaction between groups and visits, the ANOVA gives us the result that p=0.438, which is higher than 0.05, so we do not reject the null hypothesis saying that the visit does not

influence eTIV value based on whether is demented. For the assumptions, all sphericity, normality, and homoscedasticity had been met.

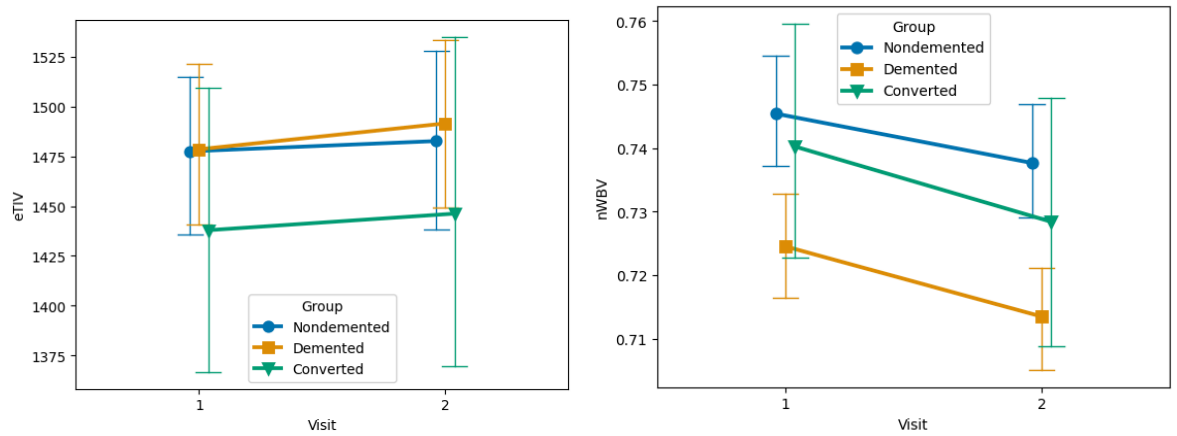

Figure 3, 4: point plot of eTIV and nWBV grouped by dementia and the number of visits.

From Figure 4, the demented group has a lower value of nWBV. The ANOVA gives us the result that p=0.219, which is higher than 0.05, so we do not say that the visit influences nWBV value based on whether is demented. For the assumptions, all sphericity, normality, and homoscedasticity had been met. Different from eTIV, the p-value of ANOVA for Group is 0.002 < 0.05 and when we apply the post hoc test (table 1), we can see that the p-value between Demented and Nondemented group is < 0.05, their mean are different.

Visit	Group A	Group B	p-value
1	Converted	Demented	0.170
1	Converted	Nondemented	0.648
1	Demented	Nondemented	0.001
2	Converted	Demented	0.205
2	Converted	Nondemented	0.429
2	Demented	Nondemented	<0.001

Table 1: Post hoc test p value of nWBV.

Research question 3

Same as research question 2, the p-value from ANOVA test of eTIV and nWBV on interaction between gender and visits are both higher than 0.05, and the individual p-value for gender and visit are both less than 0.05. This indicate that gender affact the mean of both eTIV and nWBV. This can also easily be seen in the plots below. For the assumptions, only the valence of eTIV in first visit between genders are not equal, all other sphericity, normality, and homoscedasticity had been met.

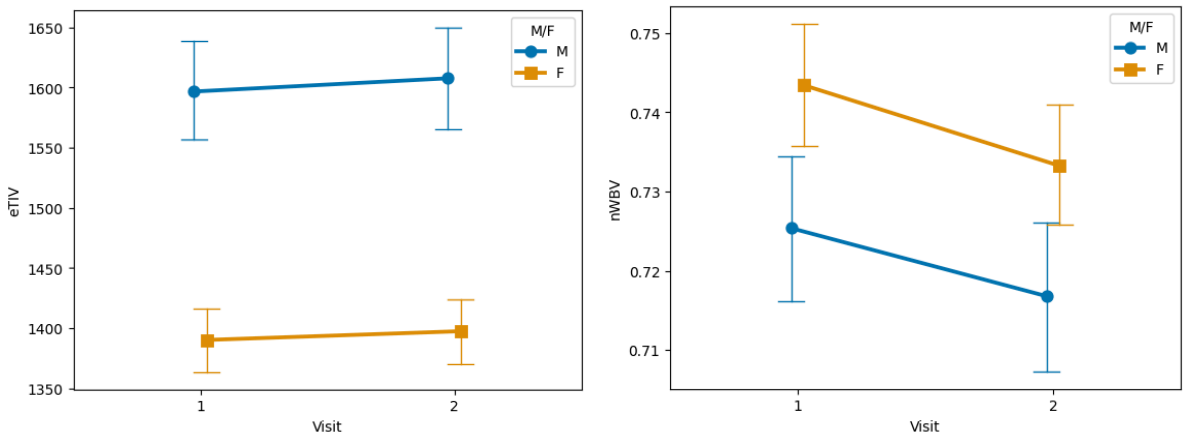

Figure 5, 6: point plot of eTIV and nWBV grouped by gender and the number of visits.

Statistical Power

When power = 0.91, effect_size = 0.70, and alpha = 0.05, the sample size needed in each group is 45.451 and the power curve is in Figure 7. All sample sizes in this analysis had been met except the number of converted participants (in column Group).

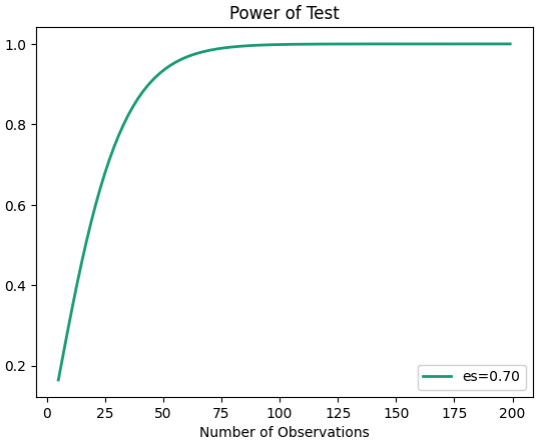

Figure 7: power curve when the effect size is 0.70.

4. Conclusion

From the results, the first conclusion is that the results of MRI are different between two visits. Compared to the first visit, the mean of eTIV is higher and that of nWBV is lower. On the other hand, from research question 2, we got that the visit does not have a significant influence on MRI results based on whether participants are demented. But from the post hoc test, we can see that the demented group has lower nWBV value than the nondemented group. From the last research question, we can see that gender affects the mean of MRI results, male have higher eTIV and female have higher nWBV. More research can be done to discover the reason for these effects. A limitation of this analysis is that the assumptions of ANOVA are not met in all cases, which lowers the reliability of the ANOVAs' results. But the statistical power had been reached in most cases. Combining other methods to solve this problem will give us a more accurate analysis.